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Biofouling on PM stainless steels

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Introduction

Powder metallurgy (PM) consists in obtaining pieces of powder metal that are processed at high temperatures and pressure. Due to its characteristic manufacturing process, the materials can have a specific and controlled porosity, which makes it possible to obtain porous parts such as ball bearings, gears, and roller bearings, etc. This porosity is what made us think about how easy biofouling would be on these materials and its possible environmental applications.

Materials and Methods

The materials studied were two different PM stainless steels (SS), a 316L austenitic SS and a 50/50 duplex SS, latter resulted from mixing 430L ferritic SS and 316L austenitic SS powders (Table 1). The mixture was obtained by dry mixing and die pressing at 700 MPa using a uniaxial press, as well as die lubrication with zinc stearate. Green samples were sintered in both vacuum and N_2-H_2 at 1250 ºC for 30 minutes. The densities of the materials obtained were in the range of 7.1-7.4 g·cm^{-3}. For the control we used conventional SS. Coupons were polished to 1 μm.

Table 1. Chemical composition and properties of the powders used

Powder grade	Cr	Ni	Mo	Si	Apparent density	Flow	Particle size
	%	%	%	%	g·cm^{-3}	s/50 g	μm
316L	16.4	13.2	2.5	0.90	3.1	25	< 150
430L	16.0	0.2	0.01	0.88	3.0	26	< 150

For biofouling tests the coupons were placed in universal bottles with 20 mL Nutrient Broth (OXOID) culture medium and sterilized by autoclaving 20 min at 121 ºC. Then they were inoculated with Staphylococcus aureus *ssp* aureus, *Rosenbach 1884, (CECT 240) at a initial concentration of 10^4 cells·mL^{-1} and incubated at 37 ºC under static conditions for 24 and 48 h. After the tests the coupons were washed twice with sterile water, fixed, dehydrated in an ascending acetonic series, critical point dried, sputtered with gold and examined under scanning electron microscopy.*

We have previously used Staphylococcus aureus *as a model for biofouling studies [1, 2].*

Results and Discussion

Staphylococcus aureus *attached to both duplex and 316L sintered stainless steels in the same way. No differences were observed in biofouling in materials sintered in vacuum or N_2-H_2. In particular, we have observed that bacteria were located mainly inside the pores (Figure 1), where the environmental conditions are better for their development.*

These results suggest that PM stainless steel could be applied to bioremediation process such as decontamination of polluted water, where planktonic microorganisms need a surface to attach and develop a biofilm.

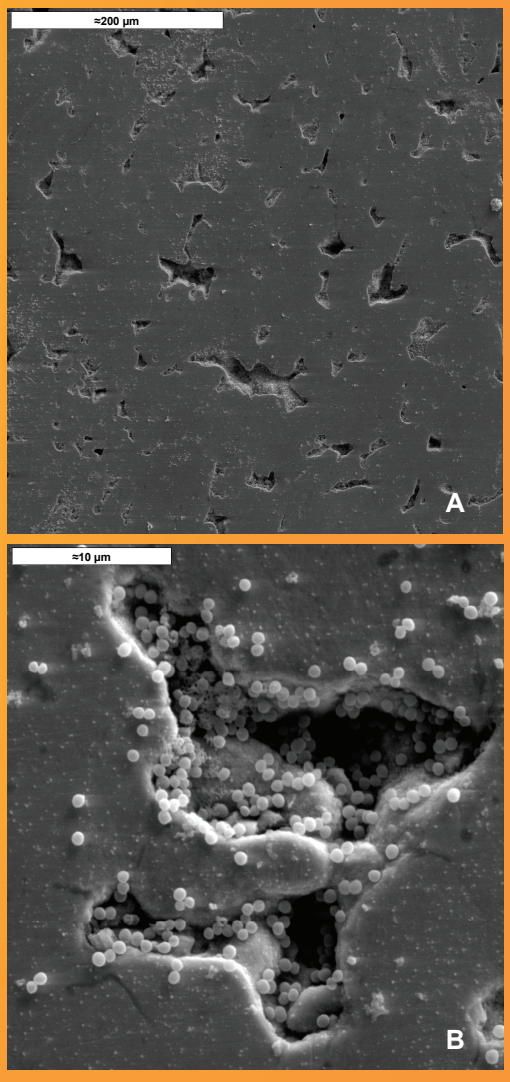

Figure 1. Scanning Electron Microscopy (SEM) micrographs of biofouling developed at 48 h on the surface of PM duplex stainless steel sintered in vacuum. A) General overview showing the material porosity (x200) B) *Staphylococcus aureus* growing inside a pore (x3,000).

Conclusion

Our preliminary results indicated that Staphylococcus aureus *colonies have a direct relationship with the porosity of PM stainless steels. However, additional investigation is still need for an in depth understanding of the biofouling mechanism.*

References

1. *Revista de Metalurgia Madrid 40 (2004) 21-29*
2. *Surface & Coatings Technology 201 (2006) 2807-2812*